Auckland Regional Council
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Review of Hydrologic Properties of Soils in the Auckland Region

May TR 2009/0072

Auckland Regional Council
Technical Report No.072 May 2009
ISSN 1179-0504 (Print)
ISSN 1179-0512 (Online)
ISBN 978-1-877528-84-2

Technical Report – First Edition

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Recommended Citation:

BURFORD, P. (2008). Review of Hydrologic Properties of Soils in the Auckland Region. Prepared by URS for Auckland Regional Council. Auckland Regional Council, Technical Report No. 2009/072, December 2009.

Review of Hydrologic Properties of Soils in the Auckland Region

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Prepared for
Auckland Regional Council

URS Reference: 42029404

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Introduction

1.1 Background

URS New Zealand (URS) was commissioned by the Auckland Regional Council (ARC) to provide technical information on soils within the Auckland region to support their work in revision of Technical Publication 108, Guidelines for Stormwater Runoff Modelling in the Auckland Region (Auckland Regional Council 1999).

URS understands the objectives of the work requested to be as follows:

- Categorise undisturbed soils found within the Auckland Region into four or five major categories based on their hydrological characteristics that influence stormwater runoff.
- Develop an electronic map in geographic information system (GIS) format that delineates the soil classes such that it can be used for selection of TP 108 model inputs for prediction of stormwater runoff.
- Provide the following soil physical characteristics for the major soil groups identified above as inputs for modelling work that will revise the curve numbers for soils:
    - Soil moisture content at saturation, field capacity and permanent wilting point; and
    - Infiltration rate.

1.2 Scope of Work

In order to meet the objectives identified above, the following work was completed:

- Data Review - Potential sources of information for characteristics of soils found in the Auckland Region were reviewed to evaluate their suitability for use in categorising soil hydrologic properties. This included review of URS internal project data and external information sources such as Landcare Research (Landcare) databases and publications.
- Compilation of Available Data on Soil Physical Characteristics – Data that was determined most relevant based on the desktop review was compiled to provide data for evaluation of potential soil hydrological classes and specific values for soil physical characteristics.
- Hydrologic Class Identification/Map Development – The data and information was then further evaluated to determine relevant relationships for classification of soils into hydrological classes for the region. Existing GIS maps obtained from Landcare

were used as base maps to identify key soil characteristics and where a lack of information is available.

- Reporting – This report was prepared to summarise the work completed.

2 Summary of Data Review

2.1 Sources of Information Evaluated

The following is a description of the information sources reviewed to provide specific parameters for soil hydrologic properties and to provide confidence in the parameters proposed as model inputs.

2.1.1 URS Internal Data

Results of site assessments conducted within the Auckland Region that included measurement of soil physical properties including particle size distribution, saturated hydraulic conductivity, porosity and moisture holding characteristics were compiled and reviewed. Selected results were used to validate the parameters proposed for use in the model.

2.1.2 Landcare Databases

The following information available from Landcare was reviewed:

- Land Resource Information System Spatial Data Layers – This is an electronic database that is available from Landcare in a geographic information system (GIS) format. It was purchased by the ARC and provided to URS for use in this project. The GIS layers contains detailed information on topography, land uses and soil properties. The data is provided electronically in layers as described in the documentation provided with the database. It incorporates data available from the New Zealand Land Resource Inventory (NZLRI) and Fundamental Soil Layers. It is believed to be the most comprehensive database available for New Zealand and is widely used for planning purposes.
- Soil Profile Descriptions - Detailed descriptions of selected soil profiles within the Auckland Region available on the following Landcare website (Landcare Research 2009).

2.1.3 Miscellaneous Publications and Web Sites

The following publications and web sites were reviewed to obtain information on how soil texture influences other soil physical properties:

City of Sacramento (2009), EPA. (1994), McLaren, R.G et al. (1990), Hillel, Daniel. (1980), Jamison, V.C et al. (1958), NRCS (2004), NZ Geotechnical Society Inc. (2005), Pedosphere (2002), Webb, T.H. et al (1995).

2.2 Selected Physical Properties of Soils

The soil physical properties that were evaluated as part of the data review are identified and defined in Table 2-1. Although, not all of these parameters are utilised for the proposed soil hydrologic classes (refer Section 3), they may become useful for future refinement the classes proposed.

Table 1

Definitions of Selected Soil Physical Properties

Soil Characteristic	Definition
Soil Texture	Relative amounts of sand, silt and clay sized particles within the soil. A soil textural triangle is provided in Appendix B as a reference to the texture classes referred to in this assessment. Soil texture may be determined in the field by an experienced soil scientist or analysed in the laboratory. In this assessment both field and laboratory classifications were reviewed.
Particle Size Distribution	Laboratory assessment that provides the percentage of sand, silt and clay sized particles to allow soil textural classification. For this evaluation, the classification systems used were not always defined and may account for some of the variability of data observed (refer Appendix B for comparison of soil classification systems commonly used). This limitation is discussed further in Section 3.1.1.
Field Capacity	Maximum soil moisture content at the time that water can be held within the soil matrix against the force of gravity. It is generally measured in the laboratory at a soil tension of 0.33 kPa.
Permanent Wilting Point	Soil moisture content at which plants can no longer remove water for their use. It is generally measured in the laboratory at a soil tension of 15 kPa.
Available Water Holding Capacity	Water held within the soil that is available for plant uptake. It is the difference between field capacity and the permanent wilting point. This value may vary for the same soil depending on the soil tensions utilised for measurement of field capacity and permanent wilting point, therefore data must be reviewed carefully to ensure that comparison of like values for this soil characteristic. For this evaluation, the values as defined in this table were generally utilised.
Total Porosity	Total pore space in the soil which is filled by either air or water. For this evaluation it has been assumed that total porosity is equal to the soil moisture content at saturation.
Infiltration Rate	Rate at which water can enter the soil from the surface measured at steady state. For this evaluation, the infiltration rate at saturation is used, since this is considered the maximum rate at which water can enter the soil for a prolonged period of time. This is also referred to as the long term acceptance rate. Actual infiltration rates at any given time will vary depending on soil wetness, cover type, slope, soil structure, clay type and other factors.

Soil Characteristic	Definition
Permeability Rate	Rate of water movement through the soil at saturation. Similar to infiltration rate, the actual permeability of the soil at any give time is dependent on many factors.
Depth to a Slowly Permeable Horizon	Depth from the soil surface to a layer encountered that is likely to restrict water movement and root growth. For this evaluation a permeability of <4 mm/hr has been used to define a slowly impermeable horizon[1].
Depth to the Seasonally High Water Table	Minimum depth from the soil surface that the water table occurs during wet seasons (generally winter and spring). Unlike the identification of water table depths using piezometers, soil scientists evaluate soil colour and presence of redoximorphic features (e.g. mottles) to identify the water table depth. Depth to the seasonally high water table is strongly influenced by landscape position with soils located on sloping areas being less likely to having shallow water tables than soils located on flat land or in depressions.

Data sources were reviewed to identify the soil characteristics defined in Table 1. A matrix is provided as Table 2 that identifies where specific information on soils is available from the data sources evaluated.

Table 2

Source of Information for Selected Soil Information and Data

Soil Characteristic	Source of Information		
	URS	**Landcare**	**Publications and Websites**
Soil Texture	X	X	X
Particle Size Distribution	X	X	
Field Capacity	X	X	X
Permanent Wilting Point	X	X	X
Available Water Holding Capacity	X	X	X
Total Porosity	X	X	X
Infiltration Rate	X		X
Permeability Rate	X	X	X
Depth to a Slowly Permeable Horizon		X	
Depth to the Seasonally High Water Table		X	
Detailed Descriptions of Soil Profiles for Selected Soils in the Auckland Region (Landcare website)		X	

2.3 Results of Data Review

2.3.1 URS Internal Data

Appendix B contains a summary of available data from URS site investigations. The review of this data indicates that only limited relevant data is available for use in this assessment due to the depth at which many of the soil parameters were measured during field investigations (deeper than the surface horizon). This is because the majority of soil investigations were conducted to evaluate the geotechnical properties of the soils for engineering purposes. In addition, water holding characteristics of the soils were not assessed in most cases.

Therefore, the data selected for use in this project were taken from a limited number of investigations conducted to assess water movement within the surface soil profile. In most cases these were investigations that evaluated soil suitability for wastewater irrigation. Table 3 summarises the soil physical properties from these investigations.

Table 3

Summary of Soil Physical Properties from URS Internal Data

Soil Type	Test Section (m bgl)	Bulk Density (v/v, t/m^3)	Total Porosity (v/v, t/m^3)	Field Capacity (v/v, %)	Wilting Point (v/v, %)	AWC Calculated (v/v, %)	Infiltration Rate (mm/hour)
Sand			34	21	8	13	
Iron Pan			38	28	14	14	
Sandy Silt	0.13 - 0.25	1.25	51	28	15	13	
Clay Loam	0.06	0.98	63	29	20	9	4
Silt Loam	0.09 – 0.25	0.99	62	29	25	4	
Silty Clay Loam	0.10 – 0.25	1.25	51	40	29	11	
Silty Clay Loam	0.04 – 0.40	1.56	41	36	30	6	
Silty-Clay	0.1 - 0.2	1.50	43	34	30	4	
Clay Loam	0.06	0.92	65	33	30	3	
Clay Loam	0.06	0.93	65	33	31	3	11
Clay Loam	0.46 – 0.61	1.35	50	40	32	8	
Clay	0.3 - 0.4	1.14	59	41	34	7	
Clay Loam	0.1 – 0.5	1.36	48	40	38	2	
Clayey Silt	Surface						2
Silty Clay	Surface						1

2.3.2 Landcare Databases

2.3.2.1 Data Description

This review has identified a general lack of soil distribution maps for the wider Auckland Region which limits the ability to undertake an assessment of the likely water infiltration and runoff at various subject localities. In the absence of this information, the only complete spatial dataset that incorporates information relevant to soil distribution is the New Zealand Land Resource Inventory (NZLRI) for land use capability. Derived from the 1:63,000 & 1:50,000 scale the NZLRI (National Soil and Water Conservation Organisation & Ministry of Works), this series of maps describes a number of physical parameters (rock type, soil type, slope erosion potential, vegetation) characteristic of spatial domains. This data set has been built upon in later years (Landcare, 2000) and now can be accessed in an electronic format. It is referred to as the Land Research (2009). The LRIS GIS data includes layers describing a number of physical, chemical and hydrological parameters over spatial domains within the Auckland Region.

Unlike the paper worksheets of the NZLRI map series, the spatial domains presented in the LRIS GIS data do not directly overlap (i.e. boundaries between soil type and drainage class do not necessarily have the same footprint). It is reasonable to accept that this would be the case in a naturally variable environment. Given that the LRIS GIS data has a number of layers that may be of specific use in the context of this project (drainage, permeability, available water holding capacity, etc.), it is necessary to assess the correlation of these layers relative to the fundamental layer referred to as SOILTYPE, against which water holding capacity properties were to be assigned. In other words, does the drainage, permeability, available water holding capacity values in the layers make sense relative to the soil type present at the same point? If the answer is "yes" then these layers may prove to be useful in a quantitative sense for this project and for use in development of GIS maps for ARC use.

2.3.2.2 Data Layers Assessed

Parameters contained within the LRIS GIS data layers that provide information on soil physical properties that are most relevant to water movement and retention and therefore the potential for runoff to occur were selected for review. These parameters are identified in Table 4. The table also provides a brief definition for each of the parameters selected. For a more complete definition of these data layers, please refer to Appendix A which contains detailed documentation for this LRIS GIS data layers.

Table 4

Parameters Evaluated in the New Zealand Land Resource Information System Spatial Data Layers

Parameter	Designator within Database	Definition
Particle Size Class	PS_CLASS	Dominant soil texture within the soil profile
Soil Texture	SOILTYPE	Soil texture of the surface soil horizon
Soil Drainage Class	DRAIN_CLASS	Depth to the seasonally high water table within the soil profile
Depth to Slowly Permeable Horizon	DLSO_CLASS	Depth to an impermeable layer within the soil profile (defined as having a permeability of <4 mm/hr)
Permeability Class	PERM_CLASS	Permeability of the least permeable soil horizon within the soil profile. Designations are S (<4 mm/hr), M (4 – 72 mm/hr) and R (>72 mm/hr)
Porosity	MPOR_S_CLASS	Air filled porosity of the upper 0.6 m of the soil horizon measured at field capacity
Profile Total Available Water	PAW_CLASS	Total available water within the soil provile to a depth of 1.2 m or the depth to rooting (whichever is less). This is calculated as the difference between soil water content at 10 kPa and 1500 kPa of soil tension. Note: there is a discrepancy between the supporting documentation for the database (refer Appendix A) and the original source of the data (Webb and Wilson 1995). In the Landcare documentation, it states that available water holding capacity is calculated to a depth of 0.9 m, while Webb and Wilson (1995) indicates that this value is calculated to a depth of 1.2 m. Because Webb and Wilson (1995) is the original source for this data, it has been assumed by URS that the profile total available water is calculated to a depth of 1.2 m.

2.3.2.3 Assessment of Layer Correlations

To evaluate the relationship of these soil physical properties to one another, correlations between these parameters were determined. To undertake this assessment, the relevant GIS layer data (notably SOILTYPE, PS_CLASS, DRAIN_CLASS, PERM_CLASS, PAW_CLASS, MPOR_S_CLASS and DLSO_CLASS) for each polygon region were exported as raw ascii data to allow spreadsheet manipulation. Qualitative values (high, medium, low) were converted to numeric values (1, 2, 3) to allow correlation coefficients to be calculated between the layers. Histograms of the class frequency were also generated for each parameter to allow an assessment of data distribution.

2.3.2.4 Correlation Coefficients

There are two layers in the NZLRIS GIS data that describe the soil textures in the Auckland Region; the SOILTYPE layer, which describes the soils in textural terms (i.e. clay loam, sandy loam, etc.) and the PS_CLASS layer, which describes the soil particle size distribution. Of these two classes, the PS_CLASS layer is populated for each polygonal region, whereas the SOILTYPE layer is complete for approximately 30% of the region. The objective of this component of analysis was to identify which of these layers more accurately reflects the other relevant hydrologic layer properties.

With the un-populated fields removed from the SOILTYPE data set the correlation between the layers is shown in Table 5.

Table 5

SOILTYPE Correlation to Relevant Hydrologic Layers (Populated Regions Only)

LRIS GIS Parameter	Correlation Coefficients for SOILTYPE
PERMEABILITY	0.12
DRAIN_CLASS	0.31
PAW_CLASS	0.35
DSLO_CLASS	0.14
MPOR_S_CLASS	0.27

These data show that there is some correlation between the soil type and hydraulic layers (notably PAW_CLASS, DSLO_CLASS and MPOR_S_CLASS). To allow a direct comparison of the PS_CLASS and SOILTYPE, the unpopulated fields of the SOILTYPE layer were assigned vales based on the corresponding PS_CLASS value. The results of this correlation are provided in Table 6.

Table 6

SOILTYPE and PS_CLASS Correlation Coefficients to Relevant Hydrologic Layer (All Regions*)

LRIS GIS Parameter	Correlation Coefficients	
	PS_CLASS	SOILTYPE
PERMEABILITY_CLASS	0.51	0.33
DRAIN_CLASS	0.30	0.13
PAW_CLASS	0.25	0.25
DSLO_CLASS	0.18	0.06
MPOR_S_CLASS	0.13	0.06
* Artificially populated for missing SOILTYPE Regions		

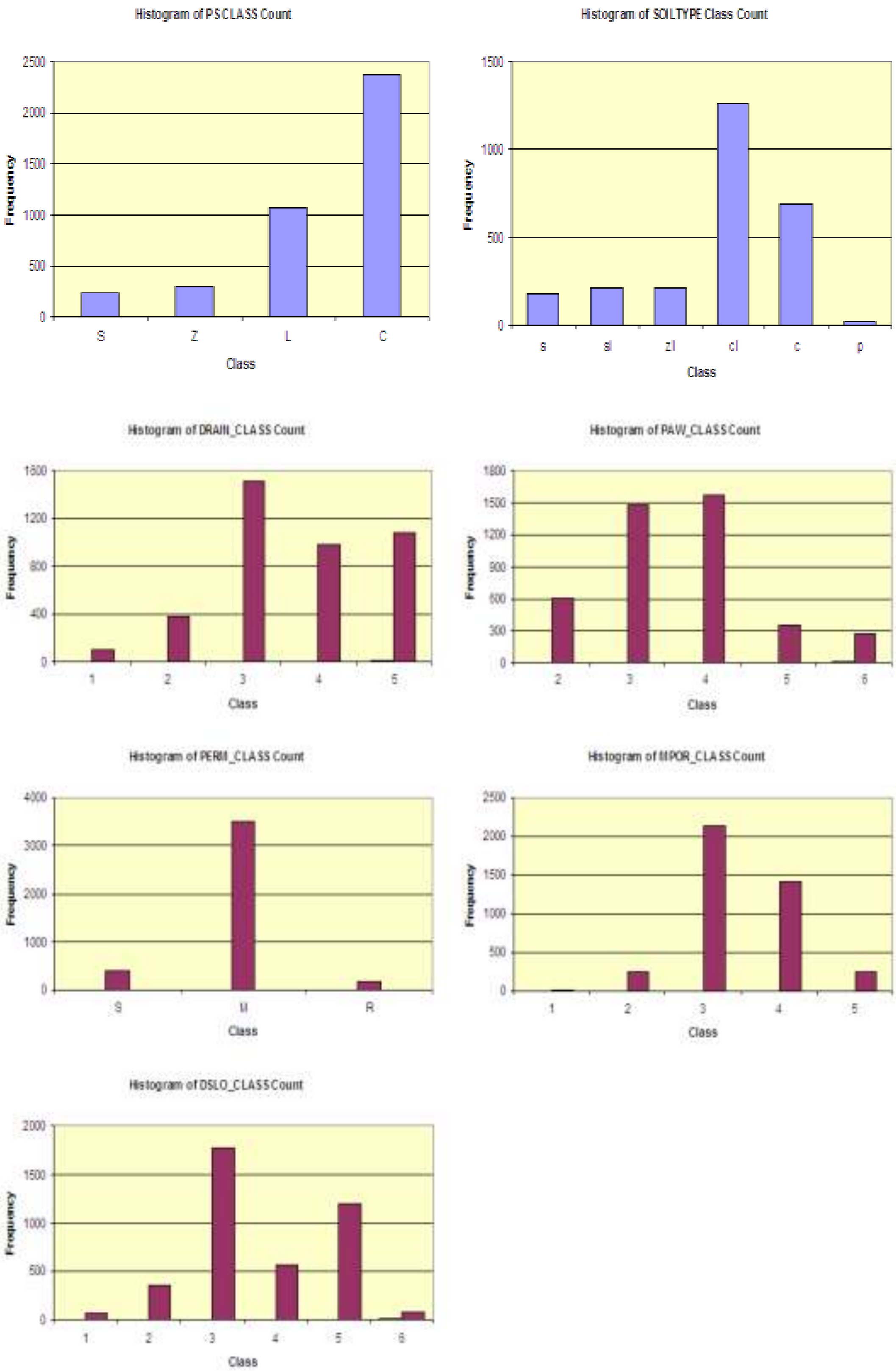
Adopting this approach the SOILTYPE correlations become poorer, while the PS_CLASS correlations show a comparable correlation to the reduced SOILTYPE data set. This analysis suggests that:

- The overall correlation of the SOILTYPE and PS_CLASS layers to the relevant hydrologic layers is weak, and therefore the relevant hydrologic layer data cannot be used in the context of this project in a quantitative manner; and
- Where available the SOILTYPE layer provides the best correlation with the other hydrologic properties in the dataset. Where unavailable, the PS_CLASS provides the next best correlation.

2.3.2.5 Data Distribution

To assist in understanding why the layer hydrologic properties do not correlate well to the soil textural and particle size layers, a series of histograms have been generated to assess the distribution of classes within each layer. These are shown in Figure 1.

Figure 1
Distribution of Data



These figures show that for the SOILTYPE layer, the greater number or class divisions provides a more normally distributed data set relative the PS_CLASS, skewed around a highest frequency in the clay loam – clay classes.

DRAIN_CLASS, PAW_CLASS, MPOR_S_CLASS also show fairly normally distributed data with a skew towards class divisions reflecting what would be expected for clay loam – clay classes. The PERM_CLASS has a normal distribution but has only three class divisions (therefore creating more polygon region overlap and generally poorer correlation), while the DSLO_CLASS layer data is typically broad.

This analysis indicates the following:

- The SOILTYPE layer more accurately reflects the soil hydraulic property layers in data distribution.
- The lesser class divisions in the PS_CLASS layer results in non-normally distributed data, heavily skewed toward the clay soil textures.
- The number of class divisions will effect how well the various layer properties will correlate for any particular polygonal region.

2.3.2.6 Conclusions

The key points to emerge from this analysis are as follows:

- Care must be taken when using the LRIS GIS data in the context of this project. There are a number of limitations of the data that mean the soil hydraulic property layers cannot be used in a quantitative sense.
- Of the soil textural data available within the LRIS GIS data, the SOILTYPE layer more closely reflects the hydraulic property layers than does PS_CLASS. Further to this, the SOILTYPE layer has class divisions that more accurately portray a normal data distribution and class divisions that honour typical soil classification systems (e.g. International Soil Science Society). Because of this, SOILTYPE is the preferred data layer to be utilised for assignment of soil texture at a specific location.
- Because the SOILTYPE layer is populated for only some of the polygons within the database, use of PS_CLASS will be required to determine soil texture at some localities.

2.3.3 Published Data

The data available from URS and Landcare databases was inadequate for assignment of values for specific soil parameters for modelling purposes. Therefore, selection of values for soil physical properties were selected based on a review of literature.

Limitations exist for use of this data, since it is not generally specific to Auckland soils and therefore may not adequately reflect soil characteristics that are unique to the region. However, selection of soil physical parameters was limited to soil properties that are commonly influenced by soil texture. The review identified relationships between soil texture, infiltration rates, water retention properties, and porosity.

2.4 Summary of Data Review

The data review identified data which could be utilised for this project and the limitations of the data. Following is a summary of how the data sources are to be utilised:

- URS Internal Data: The limited number of sites where soil investigations were conducted by URS within the Auckland Region does not provide adequate information for assignment of values for soil physical properties on its own. However, it does supplement the other published data that was used in this project and also provides Auckland specific data for comparative purposes.
- LRIS GIS Data: The soil hydraulic property layers in the LRIS GIS database cannot be used in a quantitative sense, therefore are not used in this project for assigning numerical values to soil physical properties as model inputs (refer Section 3.3). However, the data have value for this project in terms of providing data in a GIS format that includes data layers that can be used for identifying soil information at a given location for assignment of soil hydrologic classes (refer Section 4).
- Published Data: The data available from publications and web sites was utilized to provide the values for soil physical properties that are required by the ARC for model inputs. It was determined that the URS internal and LRIS GIS data did not have adequate information for assignment of these soil properties. This is further described in Section 3.

3 Hydrologic Soil Properties

3.1 Introduction

This section provides numerical values for soil physical properties required by the ARC as model inputs and proposes a method for placement of soils into hydrologic classes. The values for model inputs were developed from a review of published information. The hydrologic soil classes proposed utilise soil physical characteristics to predict runoff potential and utilise the LRIS GIS data layers when available to categorize soils within their hydrologic classes for specific locations.

3.2 Soil Texture as Basis for Assigning Soil Physical Properties

It was determined through review of available data and discussions with the ARC that the texture of the surface soil horizon should be used as the basis for assigning values for soil physical properties and for the assignment of soil hydrologic classes. Although, this is a simplified approach, soil texture is a good indicator of the soils ability to accept and retain water within the soil profile.

It is important to note that several soil textural classification systems are used internationally that define the sizes of soil particles for classification (e.g. sand, silt and clay). Although, there are similarities between these systems, the sizes of the soil separates do differ between classification systems. Because of this, different soil textural classifications for the same soil can occur. It is therefore important that the ARC specifies the soil textural classification system to be used in any guidance developed.

In New Zealand the International Soil Science Society (ISSS) system is generally used for environmental purposes while the New Zealand Geologic Society (NZGS) system is used for engineering purposes. Similarly in the United States the United States Department of Agriculture (USDA) system is used for environmental purposes and the UNIFIED or AASHO systems are generally used for engineering applications.

Because the data for New Zealand soils is incomplete for some of the parameters required, multiple data sources were utilised. Some of these data sources do not specify the soil classification system utilised. This may introduce error into the values selected for soil physical characteristics (refer Table 7).

Shirazi et Al (2001) provides a comparative analysis of the ISSS and USDA classification systems and explains the differences in these systems and how data could potentially be converted between these two systems. This conversion was not done for the data included in this report, due to limitations of the data sources.

3.3 Model Inputs for Soil Physical Characteristics

Values for the following soil physical properties based on their soil texture are required by the ARC as model inputs:

- Water content at saturation;
- Water content at field capacity;
- Water content at the permanent wilting point;
- Available water holding capacity; and
- Infiltration rate.

A range of values for each of the above parameters for five soil textural classes are provided in Table 7. The soil textures selected for inclusion within each soil textural class is based on them having similar soil physical properties as identified from review of published data.

Each of the above soil properties is influenced by factors other than soil texture, therefore, the values provided must be used with caution. It is recommended that field validation occur to provide more confidence that these values represent soil characteristics within the Auckland Region. Peat soils were not included in this assessment.

The range of values provided in Table 7 are recommended for use by the ARC as model inputs for development of runoff curve numbers. The ranges provided are estimates that were developed based on a review of available data as described in Section 2 and represent more than one data source.

It should be noted that the overlap of the range values that occurs between soil textural classes is expected due to the variability that occurs in soils. If the ARC requires adoption of a single value for model inputs, selection of a single value within the range could be substituted as a model input.

Table 7

Soil Physical Characteristics Based on Soil Texture

Soil Textural Class	Indicative Soil Texture	Water Content at Saturation[1] (% v/v)	Water Content at Field Capacity[1] (% v/v)	Water Content at Wilting Point[1] (% v/v)	Available Water Holding Capacity[1] (% v/v)	Infiltration Rate[1] (mm/hour)
1	Coarse Sand Gravel	<40	<10	<5	<5	30+
2	Sand Loamy Sand	36 – 40	8 - 17	5 - 9	5 – 10	20 – 30
3	Sandy Loam Loam Silt Loam	40 – 50	20 - 32	8 - 14	10 – 18	10 – 20
4	Silt Sandy Clay Loam Clay Loam Silty Clay Loam	45 – 52	25 – 37	16 – 22	10 – 21	5 – 10
5	Sandy Clay Silty Clay Clay	46 - 55	37 – 45	23 - 34	9 – 17	1 – 5

[1] These estimates were compiled from a review of a combination of data sources and do not represent a single data source. There estimates are not results of field investigations conducted by URS.

3.4 Hydrologic Soil Classes

As indicated previously, the ARC plans to use soil texture as the basis for assignment of soil physical properties and to estimate infiltration rates. This approach must therefore also be used as a basis for assignment of soils into hydrologic soil classes. It is recommended that in addition to soil texture, the depth to features in the soil that could potentially restrict water movement be utilised in assigning soils to a hydrologic class.

It is therefore suggested that the following factors be used for assignment of soils into hydrologic classes:

- Soil Texture: The texture of soil provides an indication of the potential for runoff to occur by taking the following factors into account (refer Table 7):
  - The infiltration rate of the soil is a limiting factor in terms of accepting rainfall during a storm event. If the rainfall intensity exceeds the soil infiltration rate, runoff will occur. Therefore, soils that have high infiltration rates would have a lower runoff potential.
  - The capacity of the soil to store water at any given time will be a function of its soil moisture content at the time of a rainfall event. The total porosity of the soil reflects the total volume of void space that is available for acceptance of rainwater. Soils with high porosity (silts and clays) have the capacity to hold and store more water than low porosity soils (sands and gravels). This means that rainfall events not exceeding the infiltration capacity or permeability of fine textured soils could potentially retain larger amounts of water before runoff or leaching occurs.
- Depth to a Restricting Layer: The depth to a restricting layer (either a seasonally high water table, or low permeability layer) can potentially increase the runoff potential of a soil, regardless of its texture by reducing the volume of soil available for retention of water at saturation. Therefore, the depth at which a restricting layer occurs in the soil becomes important in terms of placing soils within a hydrologic soil class. For example, in a sandy soil with a shallow impermeable layer (e.g. a hardpan), although the infiltration rate is high, the soil profile above the impermeable layer can be filled quickly with water and therefore increase the potential for runoff to occur. It is therefore assumed that soils with shallow restricting layers have a high potential for runoff regardless of their soil texture and infiltration rates.

Taking these factors into consideration, four soil hydrologic classes are proposed as summarised in Table 8. These classes are rated as follows:

- Hydrologic Class 1 – Low runoff potential;
- Hydrologic Class 2 – Moderate runoff potential;

- Hydrologic Class 3 – Moderately high runoff potential; and
- Hydrologic Class 4 – High Runoff potential.

Note that the use of soil texture and depth to restricting layers to place soils within hydrologic classes is a simplified approach that does not take soil structure, clay type, cover type, slope and other factors into account which influence the runoff potential of a soil.

The LRIS GIS data parameters PS_CLASS, DLSO_CLASS and DRAIN_CLASS are included in Table 8 as a reference for their use in assigning soils to hydrologic classes. Use of these parameters for assignment to soil hydrologic classes will be explained in Section 4.

Table 8

Proposed Soil Hydrologic Classes for Auckland Region

Hydrologic Soil Class	Hydro Class 1 Low Runoff Potential	Hydro Class 2 Moderate Runoff Potential	Hydro Class 3 Moderately High Runoff Potential	Hydro Class 4 High Runoff Potential	
Soil Textural Class **PS_CLASS**[1]	1 or 2 K, S, S/K	3 L, L/S	4 Z, Z/C	5 C	ALL
	AND				AND
Depth to Slowly Permeable Horizon **DLSO_CLASS**	>450 mm >1				450 mm or less 1[2]
	AND				OR
Depth to Seasonally High Water Table **DRAIN_CLASS**	>300 mm >2				300 mm or less 1 or 2[2]

[1] Use PS_CLASS only when SOILTYPE is not available within the LRIS GIS data. Peat soils all fall into Class 4.

[2] Selection of the depth to the seasonally high water table and to a slowly permeable horizon were based on the limitations of the data provided in the NZLRIS data layers (refer Section 2.3.2).

4 GIS Map

4.1 GIS Map Development

It is recommended that the LRIS GIS database purchased by the ARC be used as the base for the GIS system proposed. The data exists in a format that can be manipulated to suit the purposes of the ARC for selection and classification of soils into hydrologic classes as described in Section 3.2. Where data is missing, site specific data will be required, since no other source for this information has been identified by the data review.

4.2 Selection of Soil Hydrologic Class Using LRIS GIS

It is suggested that the LRIS GIS data layers for SOILTYPE, PS_CLASS, DLSO_CLASS, and DRAIN_CLASS be utilised to provide the information required for soil hydrologic classification of undisturbed soils in the Auckland Region. For sites where these LRIS GIS parameters are not available or for disturbed sites, field measurement of soil properties or estimates of soil properties would be required. Although the entire Auckland Region does not have data available within the LRIS GIS database, the majority of undisturbed sites are expected to have the information required to allow this classification using the LRIS GIS database.

The process for assignment of soil hydrologic classes is illustrated in the flow chart provided in Figure 2. It is suggested that this selection process be automated for the user using a web based GIS system. This would provide a useful tool that could become a web based utility for assignment of hydrologic soil classes and potentially automate other calculations relevant to TP108.

The steps that are illustrated in the flow chart are as follows:

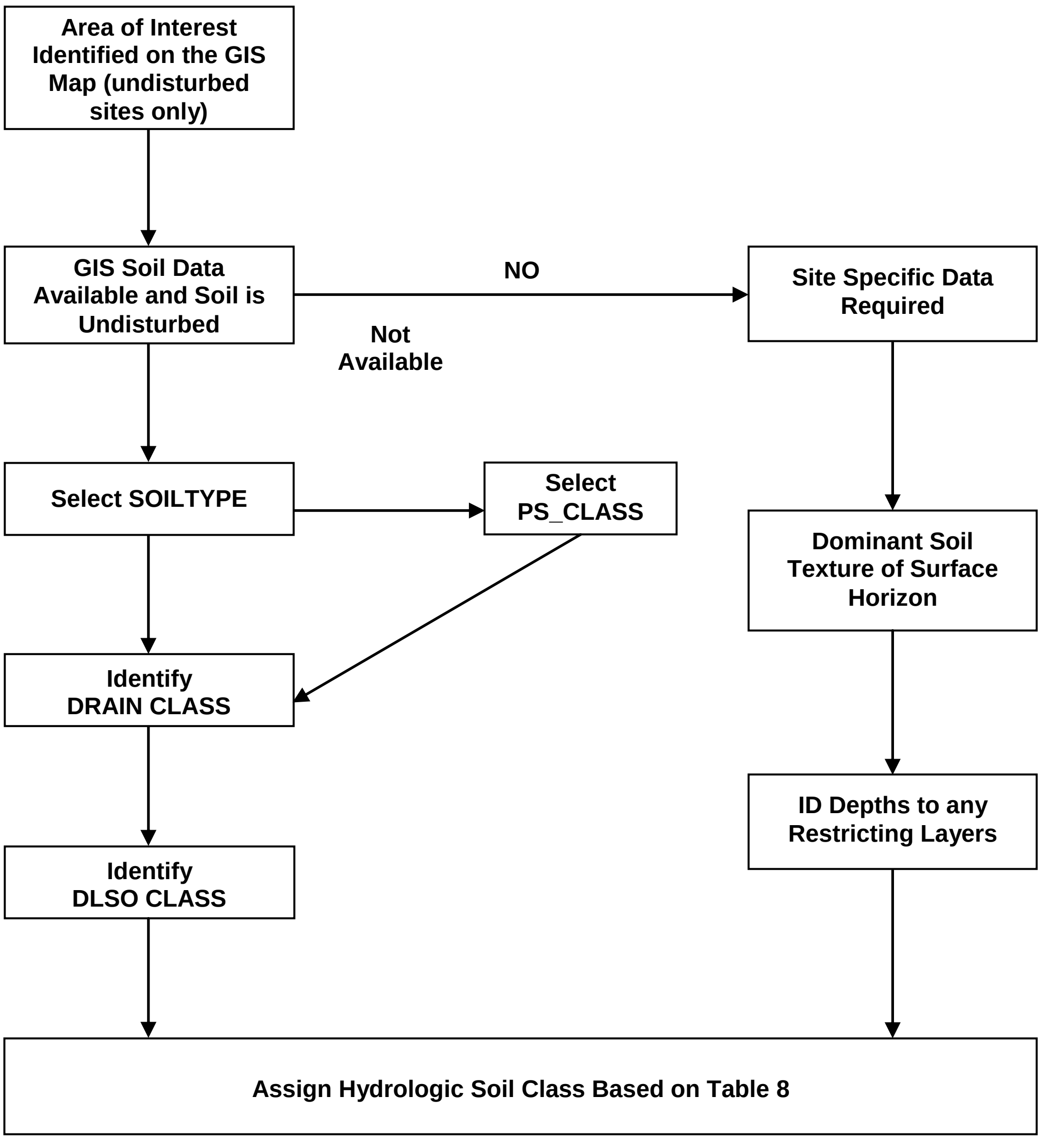
1. Select location of interest on the LRIS GIS map.
2. Determine if LRIS GIS data exist for this location and whether the soil is undisturbed. If data are not available for this location a site specific investigation would be required to obtain information on the surface soil texture and depths to the seasonally high water table and/or slowly permeable horizon. On disturbed soils additional information would also be required, since the soil properties associated with soil texture are likely to have changed due to soil compaction (i.e. infiltration rates, and soil moisture retention properties).
3. Determine the soil textural class based on SOILTYPE if available. If SOILTYPE is not populated in the LRIS GIS data then PS_CLASS should be used.

4. Determine the depth to the seasonally high water table based on DRAIN_CLASS.
5. Determine the depth to the slowly permeable horizon based on DLSO_CLASS.
6. Select the hydrologic soil group using Table 8.

Given the scale and overlap of soil properties within the LRIS GIS database the resulting soil hydrologic classes identified will provide only an estimate of the soil conditions at any given location and should not be considered a substitute for site specific investigations. Use of the database followed by field validation will be required to provide confidence in this approach.

Figure 2

Procedure for Determining Soil Hydrologic Class



5 Summary and Recommendations

5.1 Summary

This investigation utilized existing data to select soil physical parameters for model inputs and to develop a method for classification of soils into hydrologic classes for prediction of their potential for runoff. The data provided are to be utilized by the ARC in their revision of TP108 and development of constant infiltration rates.

Due to the limitations of the available data and discussions with the ARC, the following soil parameters were selected for estimating the runoff potential from a specific site:

- Soil texture (SOILTYPE or PS_CLASS);
- Depth to a restricting layer (seasonally high water table (DRAIN_CLASS) and/or slowly permeable horizon (DLSO_CLASS)).

These soil characteristics are to be selected from the LRIS GIS database purchased by the ARC for this project. It is to be used for estimating undisturbed soil properties at specific locations within the Auckland Region where data is populated in the database. For disturbed soils or areas where data are not available, site investigations would be required to obtain the missing information.

Based on the characteristics of soils, the following four hydrologic soil classes are suggested for use as follows:

- Hydrologic Class 1 – low runoff potential;
- Hydrologic Class 2 – Moderate runoff potential;
- Hydrologic Class 3 – Moderately high runoff potential; and
- Hydrologic Class 4 – High Runoff potential.

Section 4 provides the procedure for assignment of soils into these hydrologic soil classes.

5.2 Recommendations

The following recommendations are suggested to improve the confidence in the soil properties selected and to improve the access and use of the TP108 guidance under development by the ARC:

- Field validation of the soil properties for assignment of soil hydrologic groups. Results of field validation testing could be used to calibrate the model under development and provide confidence in the values selected for soil hydrologic groups. Without this validation process, confidence in the classification system proposed is limited and based primarily on assumed characteristics of soils based on their textural classification. This does not allow for unique properties of soils that may exist within the Auckland Region.
- Automation of GIS selection of soil hydrologic classes is recommended. The GIS database could be modified to allow users to select a site location and the system could automatically assign a hydrologic soil class to the area. This system could be used to simplify the selection process and reduce errors of users when making this selection.

It should also be noted that the LRIS GIS data contains data layers not discussed in this report. These layers may prove to be useful in identifying the runoff potential of the soil. It is therefore recommended that the ARC review the LRIS GIS data in the context as a potential source of other rainfall-runoff model inputs (i.e. slope, vegetative cover, permeability, etc.).

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